FINAL
ALTERNATIVE ASSESSMENT

(COVER PAGE)

Session	:	**April 2022**
Programme	:	Diploma In Electrical and Electronics Engineering (DEEI)
Course	:	**EEE1109: Analogue Electronics**
Date of Examination	:	04 August 2022(Thursday)
Time	:	12.00pm-03.00pm Reading Time : Nil
Duration	:	03 hours

Special Instructions :

This paper consists of **FOUR (4)** questions. Answer **ALL FOUR (4)** questions. All questions carry equal marks.

Material permitted :

Non-Programmable Scientific Calculator

Materials provided :

Nil

Examiner(s)	:	Dr. Hsiao Wei Su
Chief Moderator	:	Steven Khoo

This paper consists of 9 printed pages, including the cover page

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE1109: ANALOGUE ELECTRONICS
FINAL ALTERNATIVE ASSESSMENT: APRIL 2022 SESSION

Instructions: This paper consists of **FOUR (4)** questions. Answer **ALL FOUR (4)** questions. All questions carry equal marks.

Question 1

(a) Figure 1(a) shows a single stage field effect transistor (FET) amplifier and its voltage gain frequency response.

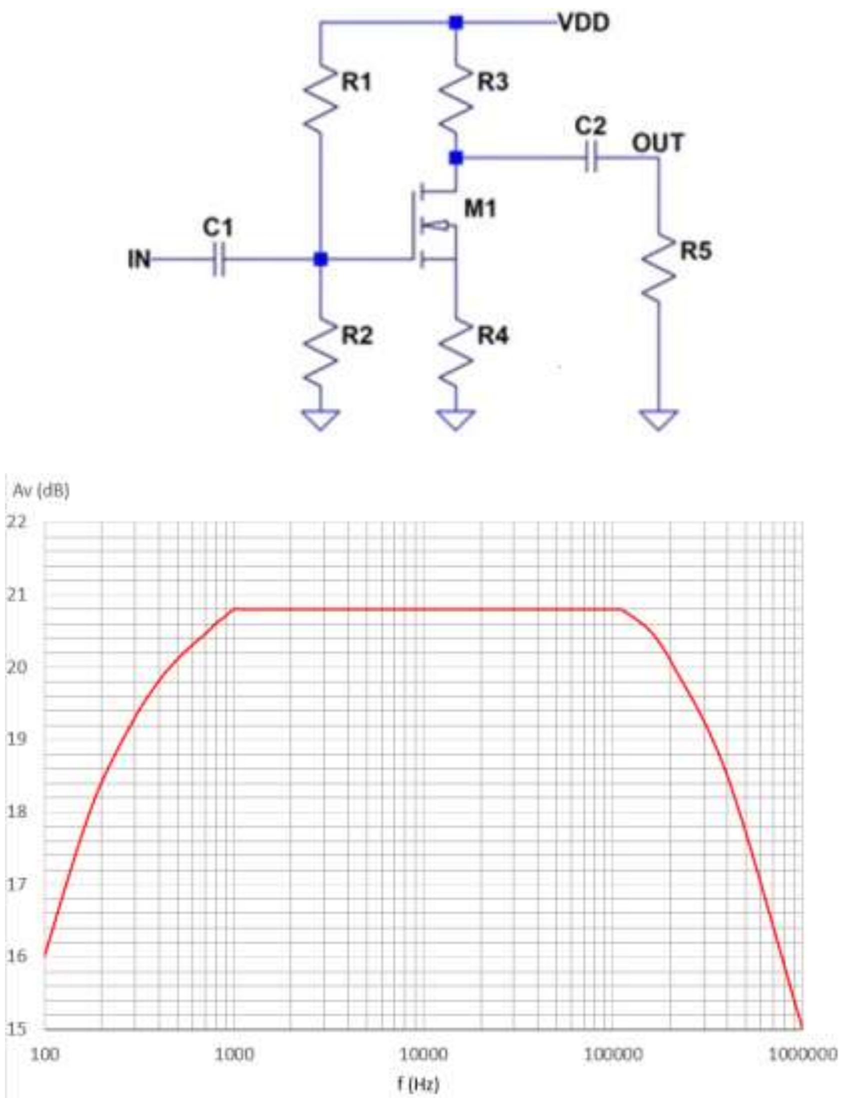

Figure 1(a)

From the amplifier's voltage gain response, do the following:

(i) Identify the maximum amplifier gain.

(2 marks)

(ii) Explain a way to increase the maximum amplifier gain.

(3 marks)

(iii) Find the upper and lower cutoff frequencies. Then estimate the bandwidth of the amplifier.

(3 marks)

(b) Figure 1(b) shows a single-stage enhancement metal oxide semiconductor field effect transistor (E-MOSFET) amplifier. The E-MOSFET has the following quiescent values: $I_{DQ} = 2mA$; $V_{GQ} = 2$V; $V_{SQ} = 1$V; V_{DSQ}=1V.

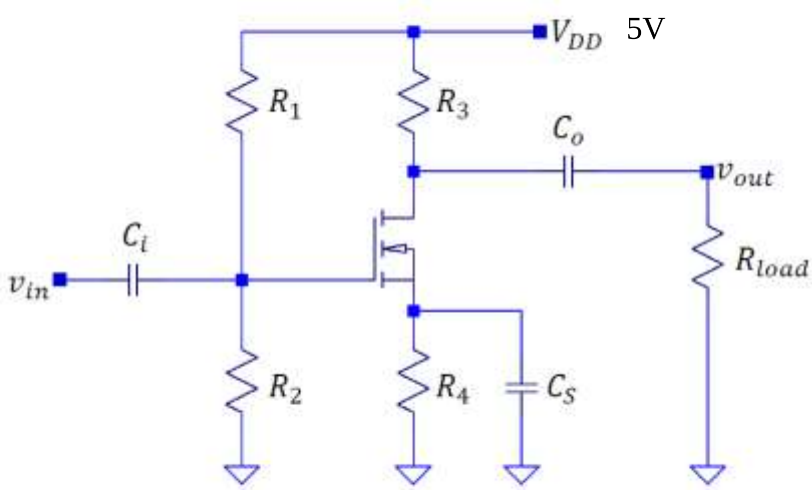

Figure 1(b)

(i) Explain the purpose of the capacitors C_i and C_s in the circuit.

(2 marks)

(ii) Calculate the resistor values for $R_1, R_2, R_3,$ and R_4. State an assumption made.

(5 marks)

(c) Figure 1(c) shows the AC equivalent circuit model of an FET voltage amplifier.

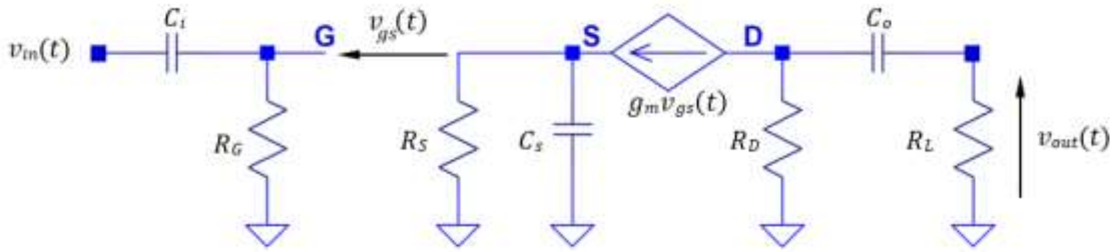

Figure 1(c)

(i) Modify the AC equivalent circuit model to evaluate the cutoff frequency contributed by capacitor C_i.

(2 marks)

(ii) Use the AC equivalent circuit model obtained in part 1(c)(i). Show that the voltage transfer function of $V_{out}(s)/V_{in}(s)$ can be expressed in the form of,

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{a_0 s}{s + w_o}$$

and state a_0 and ω_o in terms of the relevant passive components and transistor parameter, g_m. Obtain the upper cutoff frequency of the amplifier which is contributed by capacitor C_i.

(6 marks)

(iii) Quantitatively explain a way to increase the amplifier upper cutoff frequency.

(2 marks)

Question 2

(a)

(i) For the operational-amplifier (op-amp) circuit as shown in Figure 2(a), derive the expression for the overall gain as below. Assuming the op-amps are ideal.

$$A_v = \frac{V_{out}}{V_{in}}$$

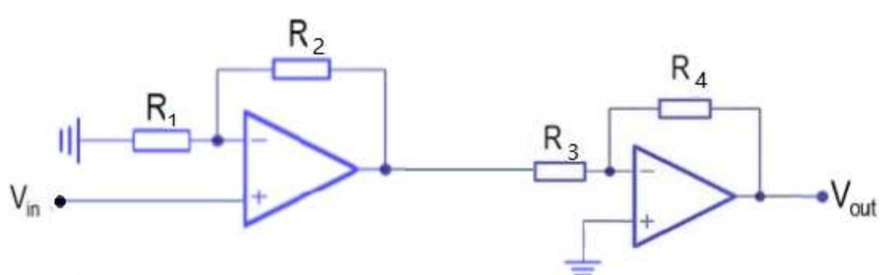

Figure 2(a)

(5 marks)

(ii) Assuming the op-amp circuit has overall voltage gain of 40dB and the first stage has voltage gain of 30dB, determine the design values of $R_1, R_2, R_3,$ and R_4. State any assumptions made.

(4 marks)

(iii) If v_{in} = 0.24sin(2000πt), suggest the suitable voltage supply for linear operation of the op-amp circuit.

(3 marks)

(b) Figure 2(b) shows an op-amp circuit implemented with the following specifications:

$V(max)$ = ±20V
$slew\ rate$ (OPA1) = 2V/µs
$slew\ rate$ (OPA2) = 5V/µs
$|V_{out(sat)}| = |Vs| - 1$ V

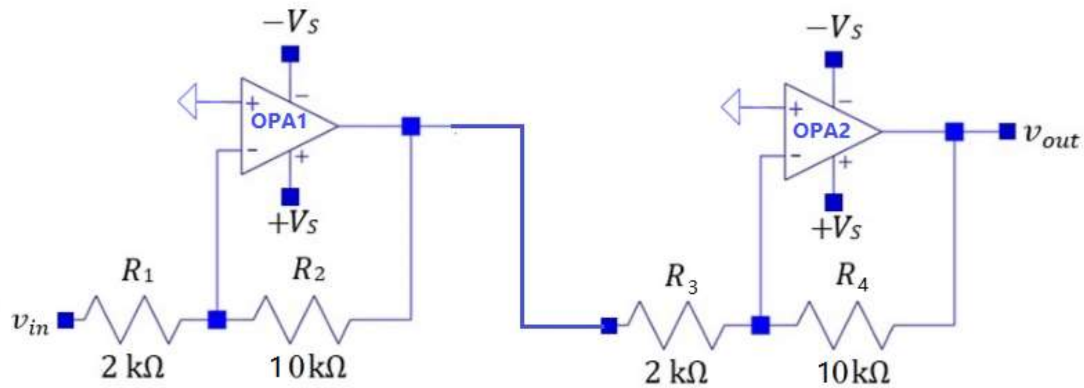

Figure 2(b)

If v_{in} = 0.75sin(100000πt), do the following:

(i) Calculate the maximum output voltage V_{out} of the op-amp circuit. Justify the suitability of the op-amp implementation from the saturation voltage point of view.

(5 marks)

(ii) Calculate the maximum rate of change of the amplifier output. Justify the suitability of the op-amp implementation from the slew-rate point of view.

(8 marks)

Question 3

(a) Copy Table 3(a) into your answer script and complete the blank cells in the table by stating two pros and cons of the listed passive and active filters.

Table 3(a)

		Passive Filter	Active Filter
Pros	1		
	2		
Cons	1		
	2		

(4 marks)

(b) A 2nd-order filter is implemented based on the cascade of 3 analogue circuit building blocks, as shown in Figure 3(b).

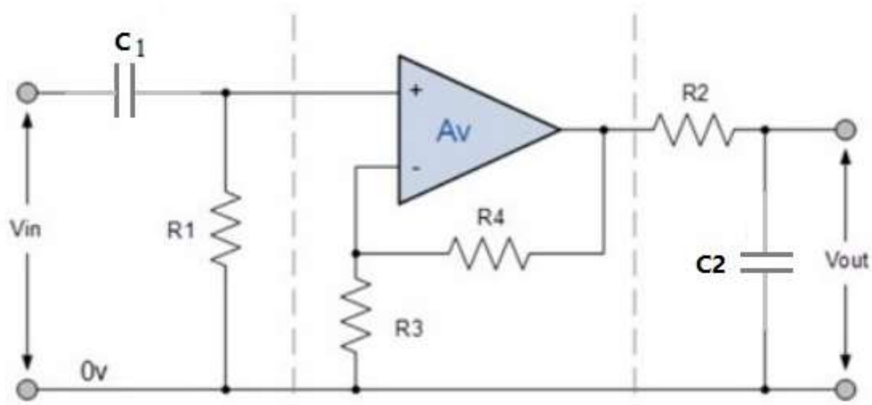

Figure 3(b)

(i) Identify and label the building stages.

(2 marks)

(ii) Based on different stage voltage transfer functions, derive the filter voltage transfer function $(V_{out}(s)/V_{in}(s))$.

(5 marks)

(iii) Identify the type of the filter based on the voltage transfer function expression obtained in part 3(b)(ii).

(2 marks)

(iv) Suggest a way to design an 8th order band-pass filter.

(2 marks)

(c) A 2nd-order passive bandpass filter is realized by cascading two different filter building blocks as shown in Figure 3(c).

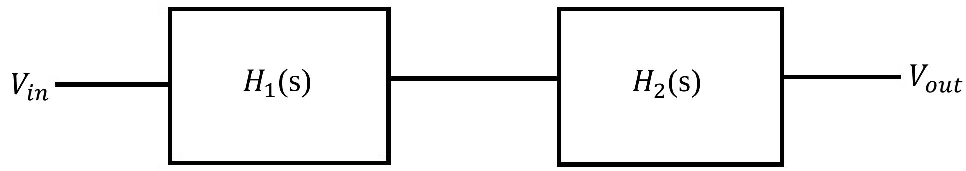

Figure 3(c)

Given that the transfer function of $H_1(s)$ as

$$H_1(s) = \frac{1}{s + 20}$$

(i) Find the transfer function of $H_2(s)$ which satisfies the overall transfer function of a 2nd-order passive bandpass filter of your choice.

(4 marks)

(ii) Calculate the filter cutoff frequencies (lower and upper) in rad/s.

(6 marks)

Question 4

(a) Briefly explain the following pertaining to an oscillator circuit.

(i) Functionality.

(2 marks)

(ii) Output design requirements.

(2 marks)

(b) Figure 4(b) shows a relaxation oscillator constructed from a 555 timer integrated circuit (IC).

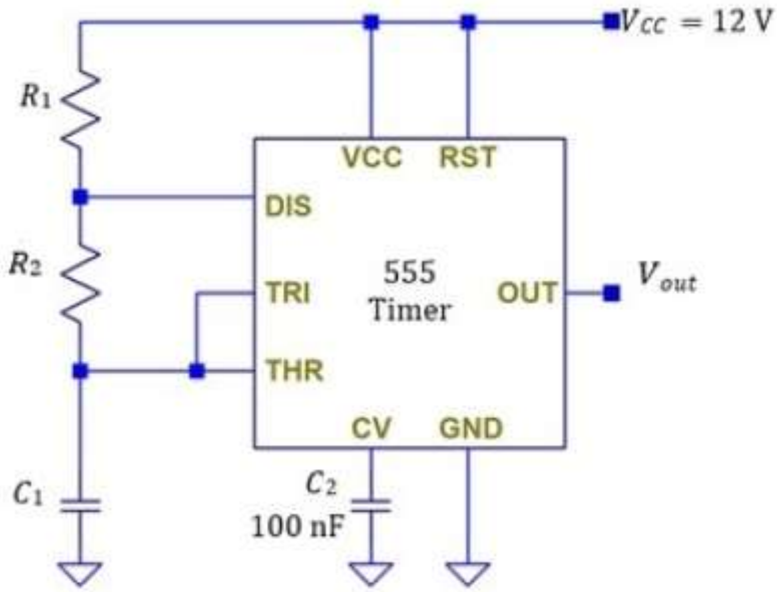

Figure 4(b)

(i) The desired oscillation frequency and duty cycle of the output signal V_{out} is 1200Hz and 88%, respectively, determine the design values of R_1 and C_1. State an assumption for resistor, R_2.

(5 marks)

(ii) Based on quantitative illustration, explain how to reduce the oscillation frequency by half and reduce the duty cycle by a factor of 1.5. State an assumption made for R_2. Show all the working steps.

(5 marks)

(c) Figure 4(c) shows a Wien Bridge oscillator circuit.

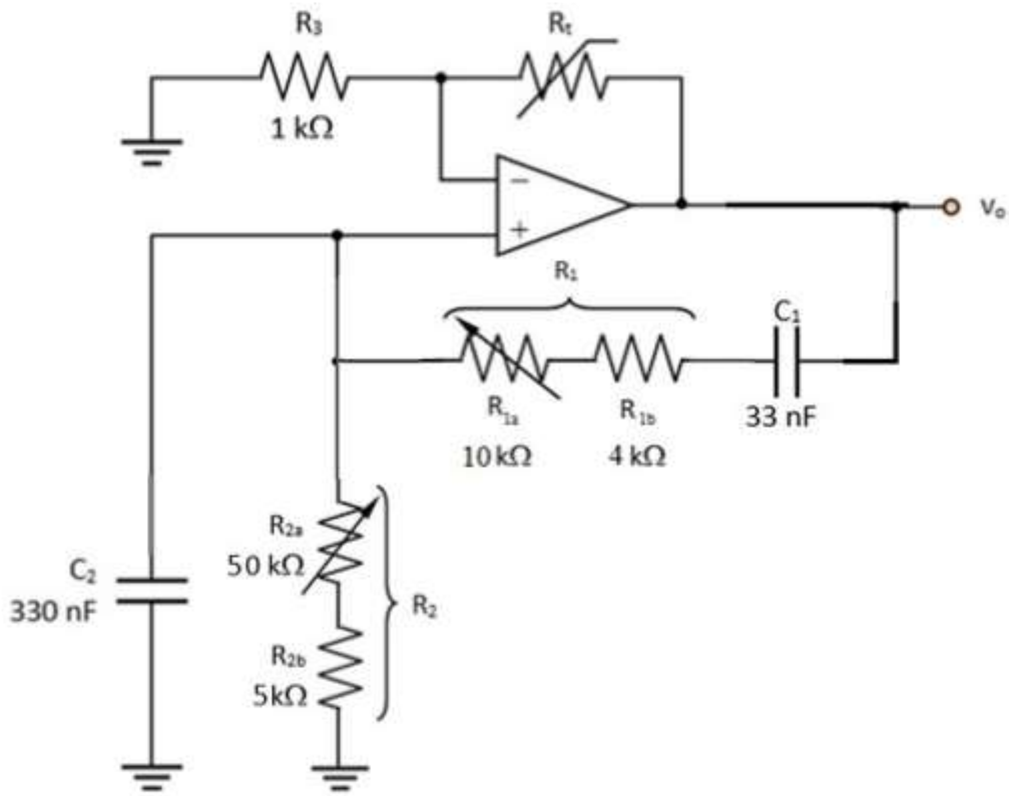

Figure 4(c)

(i) Explain the purpose of the fixed resistors R_{1b} (4kΩ) and R_{2b} (5kΩ).

(2 marks)

(ii) The positive feedback circuit transfer function is expressed as

$$\frac{V_f}{V_O} = \frac{\omega C_1 R_2}{\omega(C_1R_1 + C_2R_2 + C_1R_2) - j(1 - \omega^2 C_1 C_2 R_1 R_2)}$$

Find the expression for the resonant angular frequency.
Prove that for the circuit to sustain oscillation, the oscillator's amplifier resistor relationship is given by $R_t = 11R_3$. Assuming $R_2 = R_1$ and $C_2 = 10C_1$.

(5 marks)

(iii) From the component relationship condition given in part 4(c)(ii), determine the value or range of the thermistor R_t to (a) kick start oscillation and (b) sustain oscillation.

(2 marks)

(iv) Calculate the range of oscillation frequency when R_{1a} (10kΩ) and R_{2a} (50kΩ) are adjusted between their extreme ends.

(2 marks)

~THE END~